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Attorneys for Plaintiffs
Rearden LLC and Rearden Mova LLC

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
OAKLAND DIVISION

REARDEN LLC, et al.,

Plaintiffs,

v.

THE WALT DISNEY COMPANY, *et al.*,

Defendants.

REARDEN LLC, et al.,

Plaintiffs,

v.

TWENTIETH CENTURY FOX FILM CORPORATION, *et al.*,

Defendants.

Case No. 4:17-cv-04006-JST
4:17-cv-04191-JST

DECLARATION OF ANGELA TINWELL, Ph.D. IN OPPOSITION TO DEFENDANTS' MOTIONS FOR SUMMARY JUDGMENT ON CAUSAL NEXUS ISSUE

Judge: Hon. Jon S. Tigar
Date: To be set
Time: To be set

Ctrm.: 6, 2nd Floor

I, Angela Tinwell, Ph.D., declare as follows:

1. I am a Senior Lecturer in the Research and Graduate School on the subject areas of Games, Film and Creative Technologies at the University of Bolton. I have personal knowledge of the facts in this declaration, unless I indicate that I have been informed of a fact by others in which case I have accepted such information as true. The opinions that I express here are based on my education, experience, and academic research on human viewer perceptions of computer graphics (CG) human-like characters appearing in films, computer games, and other media, as well as the materials referenced in this declaration.

2. I have carried out numerous research projects mainly in the area of the Uncanny Valley phenomenon that relates to the areas of: Video Game Art; Video Game Design; Special Effects Development; Animation and Illustration; Character Design; Human Computer Interaction; Film Production; Creative Media; and Internet Studies. Since my first publications on the Uncanny Valley phenomenon in human-like virtual characters, my work has helped games artists, animators and special effects artists design human-like characters in industry, and has sparked much interest from the public and media. As an authority on this topic, I have been interviewed extensively for media and newspaper articles in the UK and abroad. In addition to this, I have delivered science talks to the public, consultancy to industry artists, and appeared on radio and television about my research.

3. As Programme Leader on the Games and Creative Technologies programme in the Faculty of Arts and Media Technologies, I have experience teaching practical, theoretical, and research modules in Animation and Illustration; Special Effects (SFX); Character Design; 2D and 3D Concept Art; Video Games Art; Video Games Design; also, Quantitative and Qualitative Research Methods. In addition to supervising undergraduate research dissertation projects across the areas of Games and Creative Technologies, I also supervise postgraduate and doctoral research dissertations in these subject areas. Based on the quality and impact of the research that I had done on human-like virtual characters in the SFX and games industries, I was recruited in the Research and Graduate School to disseminate research methods and the research process to doctoral level students across the University of Bolton.

4. My doctoral research focused on viewer perception of realistic, human-like virtual characters in games and film; specifically, how aspects of facial expression may evoke the 'Uncanny Valley' (Mori, 1970) response in human-like virtual characters. A viewer is likely to regard a human-like virtual character more negatively (i.e. uncanny) if there are perceived flaws in that character's facial expression. I developed a conceptual framework based on substantive empirical evidence of the uncanny and facial expression in human-like virtual characters. My research project also found that a perceived lack of empathy in a virtual character in the context of human behaviour and social cognition, would evoke the uncanny response in a viewer and repulsion toward that character, despite their intended positive or negative role on screen.

5. A copy of my *curriculum vitae* is attached as Exhibit 1.

I. MATERIALS RELIED UPON

6. In preparing this declaration, I have reviewed and considered the materials identified in Exhibit 2, which were provided to me by Rearden's attorneys.

7. In addition, I have consulted and relied upon the references listed in Exhibit 3 to my declaration, which would ordinarily be used by an academic in my field publishing a paper on the subject matter of this declaration.

II. ASSIGNMENT

8. Rearden's attorneys have asked me to express my opinion on whether the MOVA Contour facial performance capture technology has a significant impact on viewer perceptions of the CG characters whose facial animation it was used to create, and if so, to describe that impact and how it would likely affect viewer motivations to view the films in which such characters appear.

9. I have been compensated for my time in preparing this report at the rate of $500 per hour.

III. SUMMARY OF OPINIONS

10. Based on the information and analysis discussed herein, the following summarizes my opinions relevant to the assignment:

- Human beings are innately attuned to perceive subtle nuances in the facial expressions of other human beings, as we rely on this faculty for our survival.

- Based on their human-like appearance, we extend this same scrutiny to human-like animated CG characters.
- Human-like animated CG characters that lack the subtle nuances of genuine human facial expression can evoke the uncanny response and prevent the viewer from engaging and empathizing with that character due to a perception of anti-social, threatening traits in that character that cause dread, fear, and loathing.
- Prior to the mid-2000s, digital artists using conventional key framing and low density facial motion capture animation technologies were unable to impart the subtle nuances of genuine human facial expression to their animated CG characters in films and video games.
- Films featuring human-like CG characters with aberrant facial expression as protagonists were criticized by reviewers for the odd behavior and nonhuman-like traits of the CG characters, and tended to do poorly financially.
- The advent of high density facial motion capture, beginning in 2006 with the MOVA Contour technology, made the complete capture of a performer's nuanced facial expression both possible and practical for film-makers for the first time.
- Animators who used high density facial motion capture technologies such as MOVA Contour had available to them all of a performer's subtle and nuanced facial expression for animating human-like virtual characters.
- In *Beauty and the Beast* (2017), given (a) the Beast's role as a CG romantic lead protagonist character; (b) with whom the audience must empathize; and (c) with whom the audience must believe that Belle could fall in romantic love, use of MOVA Contour facial motion capture to accurately capture Dan Stevens's facial performance as the Beast was an important factor in the film's success.
- MOVA Contour technology enabled the presentation of a human-like CG Beast character that that viewers could believe in, empathize with, and believe that Belle could plausibly romantically love.

- Fewer film-goers would have seen Beauty and the Beast originally, whether in theaters, on DVD or Blu-ray, or by streaming, and fewer would have seen the film more than once, if MOVA Contour facial performance capture had not been used in the Beast's animation pipeline.
- In other words, at least some of the film's revenue can be directly attributed to the use of MOVA Contour facial motion capture for Dan Stevens's facial performance as the Beast.

IV. EXPERIENCE OF THE UNCANNY

11. The subject of "The Uncanny" was first introduced into contemporary thought by the psychologist Ernst Jentsch in 1906 in an essay entitled "On the Psychology of the Uncanny." In this essay, Jentsch described the uncanny as a mental state when a person cannot decide if an object is alive or dead or tell between what is real or unreal. Jentsch gave examples of life-like wax dolls such as mannequins that may, even for a small moment in time, confuse the viewer as they question if they are looking at a real person or not. This uncertainty may be exaggerated if viewing a life-size wax figure in reduced lighting as this may delay a person's judgment as to whether the wax-figure is actually human or not.

12. Other objects that would elicit an uncanny, eerie sensation are automata, such as machines made to imitate human movement and behaviour. An intricate mechanical doll made to look like a child and to walk or move its head and eyes may provoke 'uncanniness' (i.e. experience of the uncanny) as the viewer cannot decide whether the doll is animate or inanimate, alive or dead, friend or foe.

13. Jentsch characterised the uncanny as a disturbing and unpleasant feeling that may escalate to a shocking and ghastly experience. Furthermore, the uncomfortable feelings caused by the uncanny may stay with the viewer even after the viewer has established that an object is not real, but rather an artificial man-made object. (Jentsch, 1906).

14. Building on Jentsch's work, Sigmund Freud wanted to better understand why we find some objects frightening and unpleasant, so he conducted a psychoanalysis on the uncanny named

'*Das Unheimliche*' ('The Uncanny'). Freud described the uncanny as a unique, terrible sensation associated with all that is dreadful and abhorrent. (Freud, 1919, p. 219).

15. Freud noted that although experience of the uncanny was common when encountering a human-like artificial doll or automaton, a full comprehension and definition of the uncanny was lacking. Freud suggested that the word *unheimlich* ("uncanny" in English) signifies what is "not known" and "the opposite of what is familiar" (Freud, 1919, p. 222). The word *heimlich* can also stand for what is hidden or obscured from view to prevent others from knowing about it, so Freud used this second definition to represent the uncanny: "on the one hand it means what is familiar and agreeable, and on the other, what is concealed and kept out of sight." (Freud, 1919, pp. 224-225)

16. Freud asserted that uncanny objects evoke a sinister revelation of that which is normally concealed from human experience. For example, identifying perceived negative traits or behaviors in others that have suddenly been revealed. (Freud, 1919, p. 241)

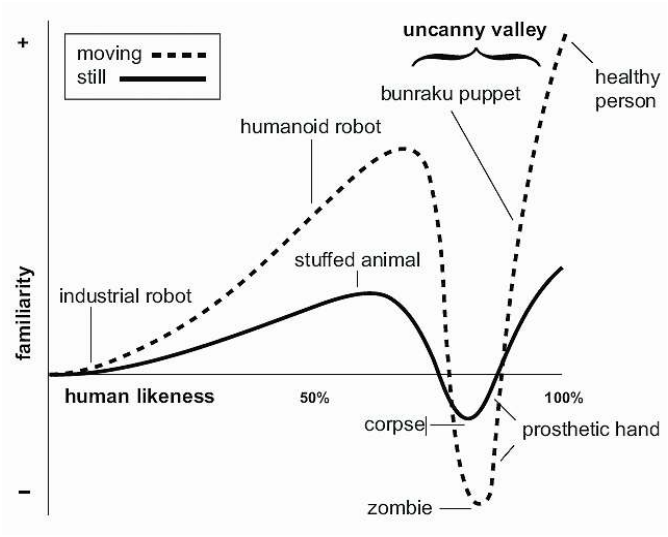
V. *BUKIMI NO TANI*—THE UNCANNY VALLEY

17. Building on Jentsch and Freud's earlier psychoanalytical literature on the uncanny, Masahiro Mori, a Professor in Robotics at the Tokyo Institute of Technology, identified a link between perceived uncanniness and robot design.

18. The latter part of the Twentieth Century saw a rapid increase in the use robots in the workplace and in society. Not satisfied with the conventional, mechanical appearance of functional robots in the workplace, engineers developed synthetic materials to mimic human flesh, skin and hair that were used to disguise and hide a robot's mechanical parts. Commonly referred to as 'androids', these robots were also designed to mimic human behavior and interact with humans.

19. Mori published an essay in a Japanese academic journal named *Energy*. Mori coined this ambition to simulate and even surpass human behavior as *Bukimi No Tani*, translated in English as "The Uncanny Valley," into which android designs may fall. Mori predicted that rather than liking the robots with a human-like appearance, people may take a more negative stance. This adverse reaction was due to subtle flaws in the robot's appearance and behavior that deviate from the human norm. According to Mori, these abnormalities in the android's movement and behavior would evoke a negative response in the viewer to the extent of fear and repulsion.

20. To illustrate this lack of rapport towards the android designs, Mori (1970/2012) created a hypothetical graph that plotted perceived affinity towards a robot against how human-like the robot appeared:



21. An industrial robot, such as a robotic factory arm, was placed at the beginning of the plot to show a more passive reaction to this type of robot. A humanoid robot, such as a toy robot, is placed further along the horizontal axis. Although this robot has some human-like features, such as face, torso, limbs, hands and feet, it still maintains a mechanical appearance. Mori reported that the viewer, *especially children*, would prefer such robots due to their human-like traits. Despite a mechanical appearance with jerky movement, children would still be attracted to the robot's simplistic human-like face and smile. (Mori, 1970/ 2012, [K. F. MacDorman and Norri Kageki, trans.] p. 98)

22. As the human-likeness in a robot increases, so does our perceived affinity, or sense of familiarity toward that robot. This dual increase in perceived affinity with human-likeness creates a linear ascent in Mori's diagram, however this positive relationship is not continuous. Mori predicted that we enjoy human-like features in robots until a certain point is reached, approaching full human-likeness, when we take a sudden dislike toward a robot.

23. Viewers expect the robot to convey appropriate, accurate, and authentic facial expressions, and to respond positively to them when they engage with it. Perceived abnormalities in an android's appearance, facial expression, movement, and behavior from the human norm evoke the

uncanny, and the android is regarded as strange and unlikeable. Perceived affinity and likeability rapidly decrease to the extent of repulsion as the android elicits an eerie, uncanny sensation in the viewer. This shift creates a valley shaped dip, which Mori coined the Uncanny Valley, into which the android falls.

VI. THE UNCANNY VALLEY AND HUMAN-LIKE CG CHARACTERS

24. Outside the field of robotics, technological advancements in hardware and software capacity and performance have allowed for increased realism in films and computer games. Specifically, CG has generated an abundance of on-screen virtual characters with a realistic human-like appearance, essentially artificial humans like Mori's robots. Yet, rather than being impressed, the audience has frequently been disappointed and put off a film or game because of the 'creepy' and 'strange' human-like CG characters that they are presented with. A similar uncanny effect to that with androids has been repeatedly identified in academia and the trade press when viewers encounter realistic, human-like virtual characters in films and games.

VII. UNCANNY FACIAL EXPRESSION OF EMOTION

A. Nonverbal Communication.

25. Facial expression is the preeminent communication tool, above that of speech and body movements (Darwin, 1872, Ekman, 2004, Izard, 1971). Nonverbal communication (NVC) takes place while we talk, especially in the upper face, and is used to understand crucial information about a person's emotional state (Ekman, 1965, 1979, 2004; Ekman & Friesen, 1969, 1978). Importantly, as well as a person's emotive state, a viewer can make accurate judgments on a person's personality, social skills, and attitude via facial NVC, regardless of their speech (Ekman and Friesen, 1969). Humans can make facial expressions both purposefully (that we are aware we are making), and involuntarily (that occur spontaneously as an automatic response to a situation). When speaking, "Conversational Actions" are purposefully made just before or with a spoken word while "Emotional Expressions" occur unwittingly to semantically accentuate the meaning of a word.

26. Due to their contrastive movements to convey positive or negative emotions, the brows are used most frequently as voluntary Conversational Actions (Ekman, 1979), therefore *animators must get brow movement correct in realistic human-like characters* (Tinwell, 2014). We

rely on these NVC signals in the upper face that are interpreted globally and intuitively because the lips and lower face may be involved in speech.

27. Additional categories of NVC in the upper face include 'Illustrators' and 'Emblems', (Ekman, 2004; Ekman and Friesen, 1969). These help to emphasize and augment what is being said and can be tied to certain words. The word "No" is exaggerated if it is spoken with a lowered brow as this facial movement is associated with negative emotions such as anger and disgust.

28. Such "baton-accents" that involve brow movement (Ekman, 2004, p.41) are directly related to a word's meaning. For example, a person speaking positive words such as "good" or "fantastic" will raise the brows. This brow lift is linked to the more positive emotions happiness and surprise, thus increasing perceived enthusiasm about what is being said.

29. The importance of context and accurate upper facial expression in a believable human-like virtual character is essential, especially during speech. If a realistic human-like character speaks the word "Excellent", but is presented with a still or a lowered brow, then the viewer may perceive that the character is being sarcastic instead of delighted with an outcome. Such an effect may occur if the animator did not animate a character's upper facial region correctly, and the viewer may be put off by the character's perceived dishonesty as they do not mean what they say (Tinwell, 2014).

B. False or Fabricated Emotion.

30. Charles Darwin (1872) found that a person's facial expression would reveal their emotional state, even if that person tried to hide how they were really feeling. As Ekman and Friesen (1969) stated, a viewer is aware of being presented with a false expression because they can detect involuntary, transient NVC that suggests possible deceit. (Ekman and Friesen, 1969, p.52).

31. The NVC leaks uncontrollable clues about a person's real emotions even if they try to control their facial expression and speech and we are hard-wired to detect that. In anger, a person can stop themselves from clenching their fist, but they cannot prevent a frown expression in their upper facial region, which a viewer will recognize as anger (Ekman and Friesen, 1969; Ekman, 2004).

32. Emblems, a specific type of NVC, are typically presented when facing another person, such as raised brows and a tilting of the head back to help communicate a person's surprise

to another (Ekman and Friesen, 1969). When emblems occur unintentionally, they can also unmask a person's true thoughts and feelings, and were likened to a verbal slip of the tongue: "Like verbal slips, emblematic fragments may reveal repressed information, or deliberately suppressed information" (Ekman, 2004). This inadvertent NVC may be as obvious to the viewer as when a person accidentally speaks their mind to reveal information not to be shared.

33. To better understand human emotion and facial expression, leading psychologist Dr. Paul Ekman and his colleague Wallace Friesen created 'FACS', a visual catalogue of the facial muscles involved in creating different expressions at differing intensity. The acronym FACS stands for 'Facial Action Coding System' (Ekman and Friesen 1978). Although it was developed in the 1970's, this facial expression classification system is still used today as the blueprint in facial motion capture and animation modeling software packages.

34. Ekman further decoded the face to develop a perceptual liar detection system based on identifying involuntary NVC, unique to spontaneous, felt emotion (Ekman, 2001, 2003). Perception of true anger requires that the lips be pressed together as well as a lowered brow. For genuine fear, the eye aperture widens to allow for increased visual field and attention, while the brow wrinkles, signaling anticipation of panic and distress. A viewer will question the authenticity of an emotion if these reliable expressions are not present to the extent that the viewer may perceive the other as lying (Ekman, 2001, 2003).

35. If a human-like CG character's facial expression is not modeled correctly and the viewer suspects a false emotion due to inadequate NVC, this can work against a protagonist CG character (Tinwell, 2014). Too many unintentional facial expressions may trigger in a viewer a perception of deceit by the CG character, and a lack of reliable, involuntary facial expressions may raise a viewer's suspicion of false emotion and invoke the uncanny response (Tinwell, 2014).

VIII. EMPATHY AND THE UNCANNY VALLEY

36. In 2009, the philosopher Professor Catrin Misselhorn put forward that uncanniness occurs because we cannot empathize with human-like, synthetic agents. We can anthropomorphize and feel emotions towards a mechanical toy robot but cannot maintain this empathy with a human-like android. I later demonstrated that aberrant facial expression may prevent a viewer from

empathizing with a human-like CG character due to a perception of a lack of empathy in a character towards the viewer (see Tinwell et al., 2011; Tinwell, 2014).

37. Emotional empathy occurs in response to "emotional displays of others" (Blair, 2005, p. 699) via their facial expression and speech. Empathy serves a vital role in effective social interaction (Caruso and Mayer 1998; Davis, 1983; Hogan, 1969; Mehrabian and Epstein 1972; Thornton and Thornton 1995). If a viewer perceives a lack of empathy in a character, they will presume that the character cannot demonstrate compassion or experience cognitive and emotional empathy with the viewer or others (Tinwell, 2014).

38. In summary, a perceived lack of empathy in a CG character works against what we would expect in terms of "normal" human response and interaction, and prevents a viewer from empathizing with that character (Tinwell, 2014). As such, *it is paramount that innovative facial motion capture techniques and animation skills communicate these more 'humane' personality traits*. If a protagonist CG character's facial expression does not accurately convey emotional and cognitive empathy in the upper face, to show that the character genuinely cares about others, then the character will likely be perceived as uncaring, cold, callous, and put in the role of an antagonist (Tinwell, 2014). This aberrant facial expression will increase the viewer's uncanny response and ultimately destroy any chance of the viewer building a relationship and empathizing with the protagonist CG character.

IX. THE EFFECT OF AGE AND GENDER ON SENSITIVITY TO THE UNCANNY VALLEY

39. Only adult participants had been used in previous Uncanny Valley experiments testing aberrant facial expression in human-like CG characters. Given that so many feature films using such characters were aimed at children, in 2014 Tinwell and Sloan conducted a study to test if 9 to 11-year-olds perceived the uncanny in animated human-like CG characters.

40. Sixty-seven primary school children rated humans, fully animated human-like CG characters, and CG characters where movement had been disabled in the upper face presenting a startled expression and happiness, for perceived strangeness, friendliness, and human-likeness.

41. As found with adults, the results showed that children do experience uncanniness in humanlike characters, perceived as stranger, less friendly, and less human-like than humans. Furthermore, children's perception of the uncanny was strongest in those characters with a lack of upper facial movement. (Tinwell and Sloan, 2014). Interestingly, we found that *nine to eleven-year-old girls* perceived realistic human-like characters as stranger than boys of the same age. Tinwell and Sloan (2014)

X. CRITICAL STUDIES OF THE UNCANNY VALLEY IN FILMS

42. The Uncanny Valley phenomenon is frequently discussed by practitioners, spectators and academics in the animation and games communities. As an important, often recurring issue in new releases that feature human-like CG characters, the uncanny topic occurs in journal papers, conference proceedings, and new media. Failure to capture the nuances of genuine human facial expression in human-like CG characters intended to be viewed by the audience as protagonists or empathetic has resulted in well-documented adverse audience responses to films. Following are some relatively recent notable examples.

Final Fantasy: The Spirits Within

43. Early 21st Century motion capture (Mo-cap) techniques used in cinematic games, animation and films such as *Final Fantasy: The Spirits Within* (Sakaguchi, 2001) served as a catalyst for uncanniness in computer generated, human-like characters. Director Hironobu Sakaguchi expected *Final Fantasy: The Spirits Within*, to be the first mainstream CG film to fully use marker-based motion capture and virtual characters with a realistic human-like appearance, and with an inflated budget of US$ 137 million, to be revolutionary and groundbreaking: "We've created characters that no longer feel blatantly computer generated… It's something people have never seen before." (Sakaguchi, as quoted in Taylor, 2000)

44. However, the audience was alarmed and disappointed on this film's release, with a mutual agreement that the main protagonist CG character Dr. Aki Ross, who was supposed to take the viewer on an emotional and spiritual journey in this story, failed to convince the viewer that she was human, or even near human-like. Jerky movements combined with unnatural and emotionally limited facial expression evoked the uncanny response. Instead of being perceived as attractive and

likeable, anomalies in her facial expression and speech made her come across as unapproachable and rude (see e.g., Plantec, 2007; Tinwell 2014; Beck, Stevens, Bard, and Cañamero, 2012).

45. As Peter Plantec (2007) stated, she inadvertently came across to the viewer as … "a cartoon character masquerading as a human. As she moves, our minds pick up on the incorrectness. And as we focus on her eyes, mouth, skin and hair, they destroy the illusion of reality. Adding a voice we recognize (Ming-Na) only complicates matters." (Plantec, 2007)

46. The audience was left so alienated by this 'phony and fake' simulacrum of Dr. Aki Ross that even today, *Final Fantasy: The Spirits Within* (Sakaguchi, 2001) is still regarded as an uncanny failure with great lengths now taken by special effects studios to avoid a similar fate (see e.g. Beck, Stevens, Bard, and Cañamero, 2012).

Beowulf

47. In 2007, Robert Zemeckis decided to improve on motion capture technologies in his fantasy film *Beowulf*. Zemeckis chose to use marker-based motion capture as it freed the actors, including Angelina Jolie as 'Grendel's mother' and Anthony Hopkins as 'King Hrothgar', from many constraints in live-action filming (Billington, 2007). With less focus on lighting, camera set up, an actor's hair, make-up, or costume, more time and precision could be placed on an actor's performance and the viewer enjoyment and experience. As Zemeckis explained, "The actors are liberated from the tyranny of a normal movie - it is absolute performance and great actors, like the ones in this movie, relish that" (Zemeckis as quoted in Billington, 2007).

48. Still compromised by the limitations of early performance capture technology, this process again failed to capture the detail, subtleties, and nuances in a character's facial expression. Despite convincing human-like CG character appearances, the audience was left to fill-in the blanks for missing nonverbal communication in close-ups of the characters' faces when speaking or listening (Gallagher, 2007). Viewers were left unmoved by dramatic scenes in the plot as those characters that were threatened or on the verge of death failed to communicate genuine fear and anger with a lack of intensity in their facial expression (Gallagher, 2007).

49. The renowned characters were perceived as odd and life-less, and film critics regarded Zeckemis as "a slave to technological advances" (Turran, 2007) for swapping "real" actors with unsatisfactory, uncanny CG replicas.

The Adventures of Tintin: Secret of the Unicorn

50. To try to avoid the uncanny in his animated near human-like depiction of Tintin in *The Adventures of Tintin: Secret of the Unicorn* (2011), Spielberg worked closely with the actor Jamie Bell and up to sixty animators at Weta Digital to ensure careful matching of an actor's observed poses with the corresponding virtual character's movements. A new facial performance capture method involved actors wearing head-rigs as they filmed their facial expressions and speech to improve both the visual and physical components of the skin texture and the underlying muscle movement and physiognomy of the face. Further deformation work was then applied to the virtual face shapes in 3D modelling software to create the appearance of muscle and fat beneath the skin. For example, so that folds and creases in the skin and wobbly cheeks would appear as a character laughed (Robertson, 2012).

51. But even with a blend of new facial performance capture and 3D modelling technology, the combined efforts of Spielberg and Weta Digital were not able to escape the Uncanny Valley. On release in 2011, the media reported that Spielberg's human-like CG characters "had fallen headfirst into the Valley and, rather than a hero, Tintin was ridiculed as a hindrance to the film (Buchanan, 2011; Rose, 2011)" (Tinwell, 2014, p. 14). His abnormal facial expression evoked negative attention as the viewer reported a sheer lack of emotional expressivity from this character. Viewers could not perceive any differentiation in the intensity of Tintin's emotion when he sat quietly contemplating a good day's work with Captain Haddock and communicating a more calm expression, to when he was being forced to jump from tall buildings and travel at high speed through busy streets in a fast-paced motorcycle chase scene (Buchanan, 2011; Rose, 2011; Tinwell, 2014).

52. Kyle Buchanan (2011) of *New York Magazine* observed that, while Tintin appeared likeable and charming, there was a mismatch between his behavior and his near human appearance "Tintin looks simultaneously too-human and not human at all, his face weirdly fetal, his eyes glassy and vacant instead of bursting with animated life".

53. Spielberg intended that the viewer be gripped by this action-packed animation, but Tintin's face did not communicate spontaneous fear or surprise in response to any perilous scenarios. Some characters found the main protagonist Tintin dull rather than dramatic and were left unconcerned if Tintin escaped from imminent danger or not. Tintin's glazed-over look and simple expression failed to match the heightened realism of the film sets and rich qualities of Jamie Bell's voice. As such, the viewer failed to engage with and care about this distant, dead-eyed, odd character.

Mars Needs Moms

54. The virtual simulation of actress Joan Cusack as Milo's Mother in the motion picture *Mars Needs Moms* was reported as disturbing with a "creepy Madame Tussauds vibe", (Schager, 2011, p.1). Instead of being perceived as empathetic, kind and likeable, she was criticized as a blight in the film for being, "strange with a wax-work complexion, dead emotionless eyes, and with the emotional fidelity of a mannequin" (Tinwell, 2014, p. 114).

55. With a lack of essential NVC in her 'wax-work' face and likened to the 'living-dead', Milo's Mother failed to convey authentic human emotion synchronized with the context of the film and the emotive tones of her speech. Milo's mother, rather than being capable of expressing empathy and love toward her family, left viewers suspicious of devious and untrustworthy traits that worked against the character's intended role as a protagonist in the film. (Tinwell, 2014).

56. Writing for *USA Today*, Ryan Nakashima described feedback from parents who had taken their children to see *Mars Needs Moms*. Doug McGoldrick, who took his two daughters to see the movie, said the faces of the main characters "were just wrong." Their foreheads were lifeless and plastic-looking, "like they used way too much botox or something," (Nackashima, 2011). Nakashima reported that another parent had said that the human-like characters were "all annoying in their own way." (Nackashima, 2011, p.1)

57. Ultimately the audience was left dismayed at the lack of emotional warmth from Milo's Mother and her family that this 'feel-good' movie was supposed to inspire. Viewers were left cold by the perceived lack of sentimentality in Milo's Mother due to her strange and inaccurate facial expression.

XI. THE FINANCIAL COST OF UNCANNY HUMAN-LIKE CHARACTERS IN ANIMATION

58. Directors such as Sakaguchi, Zemeckis, and Spielberg promoted their films as setting new heights in human drama in animation, yet a lack of human-likeness in the protagonist's facial expression prevented some viewers from having this heightened emotive experience as they failed to empathize with the characters and engage with the plot.

59. A comparison of estimated budgets and gross film takings suggests that there is a negative financial impact of uncanny human-like virtual characters in feature films.

60. *Mars Needs Moms* (Wells, 2011) had an estimated budget of 150 million dollars (Internet Movie Database [IMDB], 2011; Young, 2011), and when it was released in March 2011, it achieved a "disastrous $6.9 million opening" (Young, 2011, p. 1) over its first weekend cinema debut in the United States of America (USA). This disappointing start yielded further financial failure with gross takings by June 2011 at $21,379,315 in the United States (IMDB, 2011)" (Tinwell, 2014, pp. 192-3). And many speculated that the diminished box office performance of *Mars Needs Moms* caused the demise of Robert Zemeckis's motion-capture studio ImageMovers Digital as the uncanny human-like characters had a negative impact on this studio's reputation as well as their finances (Freedman, 2012; Young, 2011; Tinwell, 2014).

61. This is similar to the disastrous outcome for the special effects studio Square Pictures, which had the ambition to simulate human emotions in CG characters (Briscoe, 2002). With *Final Fantasy: The Spirits Within*'s estimated losses at over $94 million and CNBC recording it as the ninth biggest box office bomb of all time (Bukszpan, March 20, 2012), the closure of special effects studio Square Pictures was directly linked with this uncanny film (Brisco, February 4th 2002). Square Pictures closed due to the hyperbolic labor and costs to create the ineffective, unemotional uncanny human-like characters that the audience rejected. If the animation is too time and render intensive in that the animators have to fill in too much detail that low-density motion capture has missed, and the rendering requirements are disproportionately high compared to the actual output, then the film risks going over budget.

62. According to figures provided by boxofficemojo.com, *The Adventures of Tintin: Secret of the Unicorn*, which was criticized for the facial performance of its lead character, lost money. And *Beowulf*, also widely critically panned for its unnatural CG characters despite the casting of major film stars, roughly broke even.

63. Based on the above, *a causal effect can be identified between the initial facial motion-capture technology, unpopular uncanny human-like characters, audience acceptance, and a film's profitability*.

64. Without subtle facial movements and NVC to help communicate a character's conceptual, affective, and physiological state, the viewer will fail to suspend disbelief of the character as they are reminded that the character does not have the human capacity to think, feel, or respond to events around them (Tinwell, 2014).

65. Mori (1970/2012) placed a human beyond the Uncanny Valley dip and stated that before we can overcome the Uncanny Valley we must, "begin to understand what makes us human", (Mori, 1970/2012, p. 100). Philosophical and psychological studies can help us determine the essence of being human and apply this learning to character designs with a human-like appearance (Tinwell, 2014). The importance of upper (and lower) facial expression as a means of successful communication in human-like characters is paramount in attempting to persuade the viewer that a character does have the ability to think, feel, and respond appropriately and empathetically to others.

66. The earlier uncanny films that relied on low-density marker-based motion capture and/or key framing animation remind us of the struggles that film directors and animators had in these technologies to capture the essence of highly-nuanced human facial expressions that make a character appear human to viewers.

XII. HIGH DENSITY FACIAL PERFORMANCE CAPTURE

67. Beginning in the mid-2000s, technological innovations began to permit high density facial performance capture. MOVA Contour ("MOVA" herein) was publicly unveiled at the SIGGRAPH (Special Interest Group on computer GRAPHics and interactive techniques) 2006. "Camera System Creates Sophisticated 3-D Effects," *The New York Times*, 7/31/2006; "Digital Replicas May Change Face of Films, *The Wall Street Journal*, 7/31/2006.

68. Mr. Stephen Perlman understood the practical and theoretical difficulties in capturing the human form and the limitations that this was having on film production and audience enjoyment. Low-density motion capture could only capture partial facial movement, thus restricting animators from creating reliable facial expressions in their human-like characters. To overcome this, Perlman researched, tested, prototyped, and pioneered an innovative strategy to capture acute, comprehensive detail in an actor's facial expression as they emoted and talked. An actor's face is first covered in phosphor-based makeup, and then he or she is filmed in front of an array of lights and video cameras that work in synchrony to systematically (and imperceivably) capture all the dynamic movements of the face and skin in heightened detail, excepting only the eye ball and inner mouth area.

69. Rather than a resolution of just a few points on a face, MOVA could capture thousands of points of reference to provide millions of polygons for animators to work with. Animators now had the volumetric MOVA facial images to provide a detailed blueprint for their human-like characters and only had to track eyeball and inner mouth movement such as the tongue and teeth. The MOVA captures provided not only a guide for how the upper and lower facial regions moved, independently and in unison, but provided finer details of skin wrinkles, dimples, and folds, with subtle eye brow movements, nostril flares, and creases around the eyes and in the forehead; all of which are essential to accurately express NVC for a human-like CG character to be perceived as convincing.

70. Importantly, animators no longer had to improvise on what the face should be doing when an actor was thinking and talking. The MOVA facial captures allowed animators to work much more efficiently and accurately, creating successful human-like characters with authentic human-like expression and behaviour that matched their human-like appearance. Actors are expert at conveying authentic human expression and emotion, and MOVA allowed all of the actor's subtle, nuanced expression to be captured and retargeted to the faces of CG characters.

71. Even if astute animators had studied FACS and were aware of the vital NVC that was not available with low density performance capture, it is unlikely that they would be able to recreate every spontaneous facial movement and it would be too labor intensive and costly to manually key all of the finer nuances in facial expression precision in their human-like characters.

72. Director David Fincher realized that until MOVA had been invented, a lack of human behavioral fidelity in CG characters had served as a barrier for his Oscar winning film, *The Curious Case of Benjamin Button*, and he described MOVA as revolutionary: "Instead of grabbing points on a face, you will be able to capture the entire skin. You're going to get all of the enormous detail and the quirks of human expression that you can't plan for". (Fincher as quoted by John Markoff in The New York Times, July 31st, 2006).

73. Ed Ulbrich, Visual Effects Producer at Digital Domain, had the challenge of making Brad Pitt age backwards in *The Curious Case of Benjamin Button*, and as Ulbrich acknowledged, this film would not even have been attempted without the novel MOVA system. In a TED Talk about the making of the CG Benjamin Button character, Ulbrich stated that initially the film was inconceivable "we had to throw in the towel. It was deemed impossible. It was beyond the technology of the day to depict a man aging backwards." (Ulbrich, TED Talk, February 2009) As Ulbrich explained, the obstacle was recreating a believable virtual human, especially with a famous actor such as Brad Pitt that everyone is familiar with, "The human form, in particular the human head, has been considered the Holy Grail of our industry… there really was no tolerable margin of error" (Ulbrich, TED Talk, February 2009).

74. MOVA was first used to capture Brad Pitt performing FACS poses to create a comprehensive visual database of the parameters of what the actor's facial expression could achieve. Brad Pitt was also captured in real-time emoting and in dialogue for each movie scene, so MOVA allowed the animators to capture the idiosyncrasies of Brad Pitt's facial expression, characteristic of who he is, regardless of age (Ulbrich, TED Talk, February 2009).

75. The eighty-year-old version of Benjamin Button was created using a body actor who was smaller than Brad Pitt, and who performed wearing a blue cap to track his head motion. Before MOVA retargeting, the character appeared with an inanimate expression, referred to on set as the "Dead Head." Pitt's captured MOVA facial expression was retargeted onto a 3D model of the eighty-year-old Brad Pitt, and then transposed onto the body actor's body. This method was then repeated accordingly for each decade as the character aged backwards.

76. For the first sixty minutes of the film the viewer is watching a completely digital head of the aged protagonist Brad Pitt from the neck up. But MOVA's high-density facial performance capture allowed the richness of Brad Pitt's facial expression to match the emotive tones of his speech in keeping with the film's context and his actions in each scene. In this way, the protagonist suspended the viewer's disbelief despite Brad Pitt's age or what he was doing on screen, and heightened audience enjoyment and experience.

77. The viewer was fully immersed in the film and engaged with the protagonist Benjamin Button, rather than being distracted or annoyed by odd or unresponsive facial expression. As the first feature film to use MOVA, of three Oscars that this film was awarded, the "Best Achievement in Visual Effects" Oscar can be attributed in substantial part to MOVA.

78. Ulbrich stated that MOVA is a system that allows a virtual human-like character "to do everything that a human can do" and called the process "emotion capture" rather than motion capture (Ulbrich, TED Talk, February 2009). Animators may still take time working on a character's eyeball movement, tongue movement, hair and clothes, but without MOVA, the animators would be spending valuable time working on unsuccessful, ineffectual, inanimate CG characters. MOVA finally allowed directors and animators to effectively capture and project facial NVC in human-like characters to allow the audience to connect and empathize with human-like CG characters.

XIII. THE BEAST, AND BEAUTY AND THE BEAST

79. My research has found that virtual characters with a realistic human-like appearance may be perceived as less threatening and more humane when they portray more negative emotions such as sadness, anxiety, nervousness, self-consciousness, embarrassment, and shame (Tinwell et al., 2011a; 2013; Tinwell, 2014). Human viewers want human-like virtual characters to portray such vulnerable emotions, as well as positive emotions such as humor and hope, so that they can perceive and understand how the CG characters are feeling and thinking and so that they can empathize with the CG characters. In other words, viewers look to human-like virtual characters, in film and in computer games, to demonstrate a reciprocal range of human emotions and thought processes, so that we can truly engage with that character and trust that we have a mutual understanding and appreciation of one another.

The Library Scene

80. The importance of facial motion capture in achieving a rapport toward the Beast character is demonstrated in a video clip by Digital Domain (herein referred to as the 'video clip'), which shows how the MOVA facial scanning and capture software allows for the accurate depiction of the facial expression from the actor, Dan Stevens, to be transferred onto the animated Beast character. In this video clip, the Beast humorously refers to the books in his massive library. When Belle asks if he has read all of the books, the Beast responds humorously "not all of them, some of them are in Greek." A copy of the Digital Domain clip is attached as Exhibit 4, and a copy of the clip as it appeared in the film is attached as Exhibit 5.

81. Humour can be used as an effective means of communication to befriend and influence others (Kazarian and Martin, 2004). The initiator (in this case the Beast) understands that humour can be used to enhance interpersonal cohesiveness and to evoke a positive response in others. He understands how to make us smile and, as shown in the video clip, Dan Stevens's facial performance exquisitely expresses the joke that is then transferred onto the Beast's animated face as he muses this humorous line. In the scene, Belle immediately recognizes that the Beast is expressing a new side of his character: "Is that a joke? Are you making jokes now?"

82. The Beast's reciprocal gesture is not only directed at Belle, but also at the audience. Viewers, like Belle, are charmed that the Beast can demonstrate this sophisticated, human theory of mind, so that he can initiate a humorous response in others from his thoughts, actions, and importantly, his facial expression. This affiliative humour is affirming of self and of others (Kazarian and Martin, 2004) so we can better establish empathy with the Beast.

83. This mutual exchange of positive thoughts and feelings with the Beast allows us to build a rapport with him so that we can better understand and relate to this character. In other words, he is 'winning the viewer over' while he is encouraging Belle to like him more. The Beast's facial expression is of most significance in this exchange of emotions and humour. The Beast must portray a smile that is perceived as genuine and authentic by the viewer, and to do this the non-verbal facial expression in the upper face including the Beast's forehead and eye area must be accurate. The eye area must be involved in the smile as well as the mouth (Ekman, 1973; Ekman and Friesen, 1969).

84. Humans can create a smile shape in the lower face voluntarily, so that we can smile for a winner even though we may be disappointed we have come in second place (Duchenne, 1862; Darwin, 1872; Ekman, 2003; Ekman and Friesen, 1982). However, our disappointment will be shown non-verbally in our upper face as we cannot hide this disappointment despite our best efforts to do so. We can create a smile on our lips, but our eyes will remain the same shape or down-cast as we try to be enthusiastic for the winner (Ekman, 2003; Ekman and Friesen, 1982). When we are genuinely happy, for example if we had won, then as well as a smile shape in the lower face, the facial muscle that raises the cheek does so to an extent that the eye aperture is narrowed, gathering skin inwards around the eye socket. This movement creates bulges below the eye socket and crows-feet wrinkles to the side of the eyes, both characteristic of a genuine smile (Ekman, 1973; Ekman & Friesen, 1969).

85. This is clearly shown in a screen shot from the video clip, in which we can see Dan Stevens showing a genuine smile with bulges below his eye and some wrinkles and creases to the sides of his eyes (*see* Figure One). As well as the smile, this nonverbal communication is remodeled in the Beast character, including the details, bulges and wrinkles around the eye sockets.

86. If the Beast were to show a smile in his lower face, but a sad, or angry, or even lack of expression in his upper face due to an inaccurate depiction of facial expression, such as a furrowed brow, wide, sad eyes, or a neutral upper face, then we would instinctively perceive a false smile. As the above image shows, the MOVA facial capture software has allowed these finer nuances of the smile to be recreated on the Beast character. Without the capture of bulges and wrinkles in the Beast's skin around the eye area, we may doubt that he is feeling a more positive emotion. In this way, we would interpret that the Beast is smiling, but he is not actually happy so we may be confused as to what the Beast is trying to communicate to us. Is he attempting to trick Belle into thinking that he is joking with her (and the audience), when he is really plotting an evil plan to persuade Belle to like him while he has other more negative intentions? The Beast may convince the audience that he is capable of more human thoughts and emotions, but without modeling highly nuanced facial capture, this more sophisticated theory of mind could work against the Beast so that he is perceived as a cunning enemy to us and Belle, rather than a likeable, humorous ally. Without the perception of a genuine smile, in which the areas around the eyes must be involved and animated correctly, we may perceive that the Beast is trying to trick us and that he is Belle's enemy and a possible threat.

87. In summary, it is imperative that the finer nuances of the facial expression around the eye area are captured accurately and then modelled onto the Beast's face, and the MOVA facial capture software has allowed this to happen. The MOVA system has provided a road map for animators to ensure accuracy of facial expression in the upper and lower face, simultaneously and together, in keeping with the jovial emotive tones of the Beast's speech. Without MOVA, the Beast's facial expression may not be as accurate, engaging, or effective, so that the viewer may be unable to empathize with the Beast, or at worst perceive the Beast as a potential threat. As the details of skin texture, tone, pores, and hair increase, so does the discernment on the part of the viewer for detecting facial expressions that deviate from the human norm (Tinwell, Grimshaw and Williams, 2011b.)

88. Therefore, MOVA facial performance capture is crucial in achieving the correct facial expressions for the Beast that match the emotive tones of his speech and the context in which an emotion is being presented in the scene. Digital Domain appears to have chosen this clip to

demonstrate the capabilities of the MOVA facial capture to capture the subtleties of the actor's facial expression so they are faithfully retained in the animated Beast character. If the MOVA software can be used to enable the simulation of sophisticated human emotion, such as humor and a genuine, felt smile, then the software was doing what it was supposed to do: to enable natural human-like traits and facial expression in a CG character that the audience can grow to accept and empathize with because of these human-like behaviors, thoughts, and expressions.

The Waltz Scene

89. One of the most popular scenes in *Beauty and the Beast* (2017) is the Waltz Scene with Belle and the Beast. A copy of this clip is attached as Exhibit 6. Not a word is spoken, so the intensity and heightened viewer engagement relies on the non-verbal facial communication between Belle and the Beast. When Belle first approaches, the Beast does not have to say anything as we can clearly see from his facial expression that he has affection for her. A distinct flaring of the Beast's nostrils, a raising of his brows, and a quiver of his lips as if trying not to gape his mouth open and to maintain his composure as the sides of his mouth turn upwards, all successfully communicate his surprise and appreciation at how beautiful Belle looks. As they join hands and walk to the ballroom, we can see the anxiety in the Beast's forehead as his brows lower and form a frown line between them at the top of his nose, demonstrating how nervous and anxious the Beast is that things go well between him and Belle.

90. The Beast then looks around the grand ballroom, turns back to face Belle and immediately relaxes his forehead, but lifts the outer corners of his brows, which corresponds with the upturned corners of his mouth and tilting of his head, at which point we can see that he is checking with Belle, if she is OK? Belle responds with a reassuring smile and then curtsies before the Beast, to which he bows back to her.

91. When Belle reaches her arms and hands out to the Beast with both palms facing upwards, the Beast expresses his delight at this invitation to dance with Belle. The corners of the Beast's mouth raise even further at the same time as his inner and outer brows fully lift to widen the Beast's gaze and to spontaneously communicate his surprise as he takes her hands. As they dance, we can see that the Beast has his full attention on Belle, with an intent, compassionate, and proud

expression. This is demonstrated as the Beast's outer eyebrows lift, stretching the skin across his forehead, his cheeks lift forming small creases in the outer corners of his eyes, his nostrils flare creating wrinkles at the top sides of his nose as the skin creases and his lips curl upwards while protruding forward in a closed smile.

92. The viewer can perceive that the Beast grows in confidence as they dance, as he maintains his raised brows, raised cheeks and lips curled upwards but pressed tightly together, to communicate his assurance that things are going well and that Belle is enjoying herself. As they stop dancing, the Beast's upper and lower face fall together and he looks downwards, more uncertain of himself again. Yet, when Belle links arms with his and they turn to walk off the dance floor, the Beast's brows and forehead lift, opening his eye aperture and the corners of his mouth turn upward again as his head lifts and looks upwards, so the viewer can perceive renewed hope and contentment in the Beast's face.

93. These more complex expressions of emotions that the viewer can perceive in the Beast would not have been possible without capturing the full range of facial expressions that Dan Stevens performed in his MOVA facial performance capture that were retargeted onto the animated Beast. *It is the Beast's anticipation that is shared with the viewer that makes this scene such a success; the viewer genuinely feels nervous for the Beast as we can see nervousness in his face and we share those nerves with the Beast*. The Beast character was able to communicate more vulnerable and human traits that the viewer could relate to, and thus instilled hope in the viewer that things would work out positively between him and Belle.

94. The viewer must be able to see the man that Belle can fall in romantic love with beneath the Beast's exterior, and the MOVA system allowed for that to happen. The audience is moved emotionally because they want the Beast and Belle to be happy. They understand the Beast's affection for Belle and they want their relationship to be a success because they can empathize with him and with her.

95. This scene would be ridiculed or rejected if the viewer cannot perceive a man as a romantic lead within the Beast, the man with whom Belle can fall in love. For the viewer to be convinced of the romantic love story between Belle and the Beast that is so intrinsic to this film, the

viewer must be persuaded that a man is really there. And it is the Beast's human-like facial expression captured by MOVA that persuades us of more humane, empathetic traits in the Beast that contributed to this film's success.

The Snowball Scene

96. Another well known clip is "The Snowball Scene," in which the Beast appears shocked and surprised when he is hit from a snowball thrown by Belle. A copy of this clip is attached as Exhibit 7. The viewer can clearly see his spontaneous startled response as his eyebrows lift to open his eye aperture causing creases in his forehead, and his mouth opens to signal this heightened emotional state. Without the reliable NVC in the Beast's upper face to signal surprise, he would look odd and strange with mouth agog as the viewer may not fully understand why he appears with his mouth open. I found in an earlier experiment with realistic human-like virtual characters that a lack of upper facial movement when presenting surprise evokes the uncanny in the viewer as they are reminded of a rigamortic, zombie-type state in a character (Tinwell et al., 2011a). In this case, MOVA has allowed for the successful capture and communication of the startle response in the Beast, to help avoid the uncanny and a 'Frankenstein's Monster' effect when the viewer cannot read the Beast's facial expression.

97. When the Beast throws a snowball at Belle in return, the Beast's facial expression first shows a mischievous look of concentration as he watches where the snowball will land, with inner brows lowered, lips pressed tightly together, and his mouth tilted upwards to one side. Then, his upper face relaxes and he suddenly breaks into a wide open genuine smile as he takes playful delight in hitting his target, Belle. The viewer can see that this is a true expression of happiness as the Beast's cheeks raise with the corners of his mouth, causing bulges under his eyes and deeper creases to the sides of his eyes, both reliable signals of genuine, felt happiness.

98. This scene has demonstrated the playful side in the Beast both to the audience and to Belle, which convinces us via his facial expression that the man within the Beast has a more lighthearted and good-natured personality in contrast with the Beast's more serious demeanor.

The Dinner Scene

99. An important scene that was captured using MOVA involves the Beast and Belle sitting together at a dining table to have a bowl of soup. A copy of this clip is attached as Exhibit 8. As another mute scene, this clip relies on the exchange of facial expression between the Beast and Belle for the viewer to understand what is going on with the characters. Before the Beast lifts the bowl of soup to his lips to drink, the Beast hesitates and lifts his head to look at Belle with his inner brows squeezed together to form a frown line on the upper bridge of his nose, his lips pressed tightly together, corners turned downwards with his upper lip protruding over his lower lip. In doing so the Beast communicates the more complex emotions of shame and embarrassment, as he is frightened to offend Belle by drinking from the bowl. Belle responds by putting down her spoon and lifts her bowl to her mouth to drink.

100. The Beast's frown intensifies with deeper lines on his forehead and he opens his mouth slightly in disbelief to communicate that he is confused by what Belle is doing. As the Beast realizes that Belle is drinking from the bowl to show that she accepts his behaviour and does not want to make him feel uncomfortable, the Beast appears less tense as his eyebrows lower and the corners of his lips turn upwards. These subtle facial movements signal the Beast's understanding and appreciation of Belle's actions. They drink together. Once finished, they share a reciprocal smile that communicates the Beast's appreciation and Belle's growing acceptance of him.

101. MOVA has permitted the subtle complexities of self-consciousness to be effectively communicated in the Beast via his facial expression. These more complex, human emotions that the Beast communicates convince us that there is a man beneath the Beast's exterior who is cognitively and emotionally aware of how he is perceived by others, and what others may think of him. Such behaviour allows the audience to empathize with the Beast, because we understand why he feels embarrassed and we are just as relieved as he is that Belle has responded positively towards him.

XIV. DECLARATION AND TESTIMONY OF DR. HAO LI

102. I have reviewed the transcript of the deposition of Dr. Hao Li, and have the following comments.

103. At page 52 line 4 to line 24, Dr. Li confirms my findings that human beings are highly attuned to subtle details in natural and CG faces, and that perceived unnatural expression or motion in CG faces is likely to cause the uncanny response in viewers.

104. At page 52 line 25 to 55 line 23, Dr. Li confirms my opinion that hand animation technology such as key framing is less accurate in rendering natural facial expression or motion and significantly more labor intensive than dense motion capture technologies such as MOVA Contour. While hand animation technologies may produce adequate results in some applications, for example, when a CG character is at a distance or in a shadow, these technologies are too crude to efficiently capture all of the subtleties and nuance of an actor's facial performance.

105. At page 54 line 16 to 55 line 7, I agree with Dr. Li that traditional animation techniques can result in a CG character having inconsistent facial expression from scene to scene. A character's facial expressions and mannerisms must be consistent throughout the film, to ensure that the audience perceives the character as real and can feel familiar with his characteristics and portrayed personality.

106. At page 65 line 12 to page 68 line 5, Dr. Li confirms my opinion that for CG characters, human faces must be captured at very high resolution, because lower resolution capture technologies such as traditional marker-based technologies and hand-animation such as key framing cannot accurately represent the subtleties and nuances of the subject's face, and the resulting CG character is likely to cause the uncanny response in viewers. Those subtleties and nuances of expression "come for free" when using high resolution facial performance capture systems such as MOVA Contour.

107. At page 147 line 2 to 148 line 13, Dr. Li underscores the problem with trying to achieve authentic human facial expression using traditional technologies such as hand animation or key framing. If time and budget were not a consideration, if as Dr. Li states you have an infinite amount of time, these traditional technologies can in theory provide "good" or "adequate" results. But in the real world, where films are subject to strict production deadlines and budgetary constraints, I agree with Dr. Lee that even a window of three months would not provide sufficient time for artists using traditional techniques to produce CG animation of the same level of quality that

high density facial performance capture technology such as MOVA Contour inherently provides. And that is true, even taking into account (as Dr. Li does in the testimony cited here and in more detail in his declaration), that high density facial performance capture data requires some manual cleanup.

108. At page 148 line 15 to 150 line 7, Dr. Li defines the uncanny valley phenomenon too narrowly in my opinion. He appears to confine the uncanny response in viewers to digital characters that are "a real human," like the Paul Walker character in *Fast and Furious 7*. He draws a contrast with the aliens in the film *Avatar* where, he states, their "weird colors" and "significant [anatomical] difference to a real human" avoids the uncanny response. Another example he offers is that of the giant gorilla in *King Kong*, to which he states the uncanny response does not apply. But Dr. Li fails to take into account CG characters that fall between his binary extremes—real humans versus aliens and gorillas—such as the Beast in *Beauty and the Beast*, who must be perceived by the audience as simultaneously a beast *and* a "real human." MOVA Contour's high density facial motion capture of Dan Stevens's facial performance provided authentic subtle facial expression without which the audience would not have perceived the "real human" within the Beast in my opinion.

109. As Dr. Li concedes at page 151 line 3 to 152 line 12, the uncanny valley exists on a continuum from things that are perceived as less human to those that are perceived as more human, with sensitivity to flaws in motion and expression increasing along that continuum. Unlike aliens and gorillas, the Beast character must be recognizably human to the audience for the love story to succeed with viewers. In my opinion, the same sensitivities to flawed human facial motion and expression that provoke the uncanny response would prevent the audience from feeling empathy with the Beast.

110. In paragraphs 26-27 of the Declaration of Hao Li, he states that after the dense facial performance capture (such as MOVA Contour) is retargeted to a target rig (the digital model of the CG character's head and face), "hundreds or even thousands of hours of human labor and artistry" are required to complete the CG character, including modeling, hand animation, rendering, skin texturing and coloring, secondary components (such as eyeballs and hair), and lighting. If his point is only to enumerate the steps in the animation pipeline between retargeting of dense facial

performance capture data and the complete CG character, I do not disagree that the steps he described may be part of the animation pipeline for a CG character. But if he means to imply that MOVA Contour facial performance capture is trivial to viewers because the animation pipeline requires these additional labor-intensive steps, I disagree with that implication. MOVA Contour facial performance capture is significant to the animation pipeline precisely because it inherently provides—"comes for free" as Dr. Li wrote in his dissertation—the authentically subtle and nuanced facial expressions that viewers require to perceive a CG character as human and empathetic, and which cannot be provided by substituting labor and artistry in a real world of budgetary constraints and production deadlines.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on November _17th , 2020 Signed in _Chester__, the United Kingdom, by:

Angela Tinwell, Ph.D.